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Kwon

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(54) **METHOD OF BLASTING USING JET UNITS CHARGED IN A BLAST-HOLE**

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F42B 1/028 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***F42B 1/028*** (2013.01); ***F42B 1/032*** (2013.01); ***F42D 1/08*** (2013.01); ***F42D 3/04*** (2013.01)

(58) **Field of Classification Search**
CPC F42D 1/00; F42D 3/00; F42D 3/04; F42D 1/04; F42D 1/08; F42D 1/10; F42B 3/08;
(Continued)

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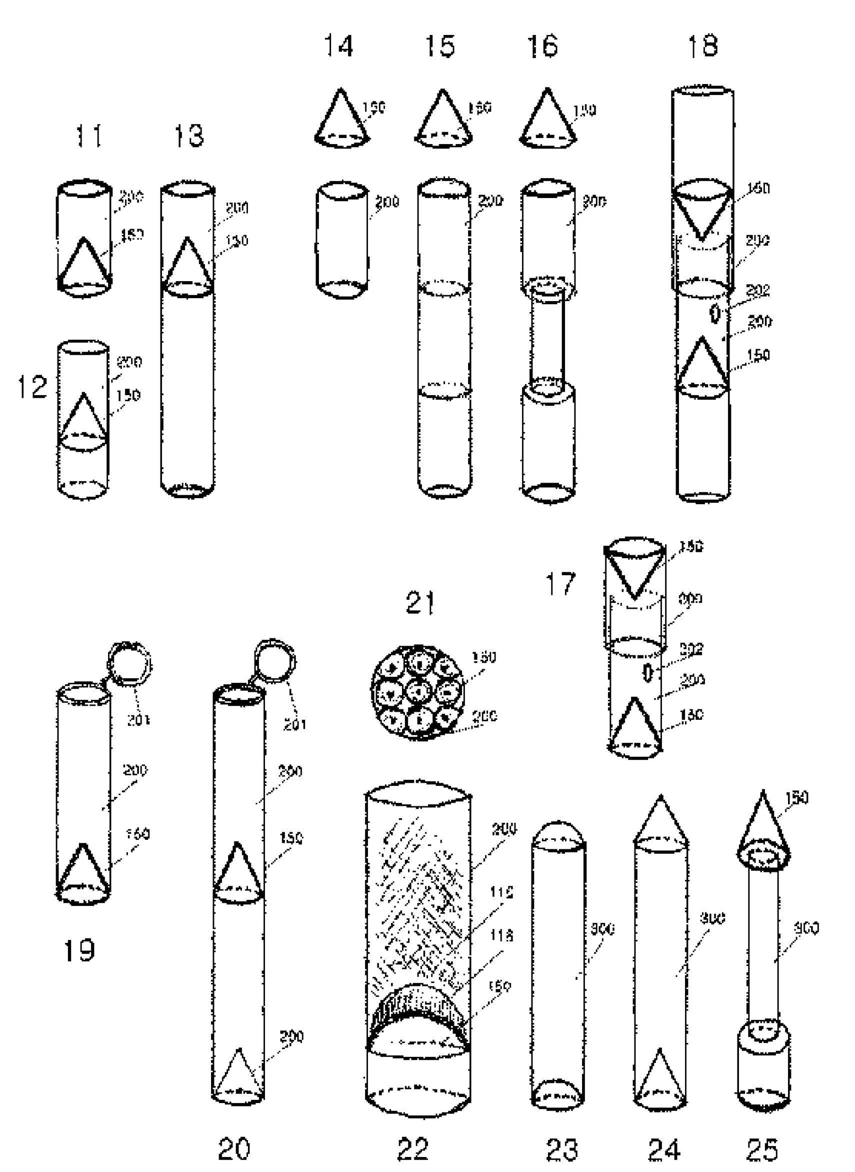
(57) **ABSTRACT**

Liners (**150**), fittings (**11**-**22**), and spacers (**23**-**25**) are provided to assemble the jet (**170**) units, which work as explosives (**110**) and detonators (**120**) to form stand-off distance and air-deck (**140**) space. The liners (**150**) release jets (**170**) and the fittings (**11**-**22**) and spacers (**23**-**25**) are designed to attach the liner (**150**) firmly to the explosives (**110**), inducing the cavity effect. The objective of the present invention is to provide a blasting method using a jet (**170**) unit to overcome the limits of sympathetic detonation, applying a mechanism that is ideal according to the analysis of observations in blast-hole (**100**) blasting. The application of jet (**170**) units for jet (**170**) detonation in blast-hole (**100**) blasting overcomes the performance limits of explosives (**110**) manufacturing and the conceptual limits of detonators (**120**) functionalities and improves the channel effect, dead pressing,
(Continued)



loss of power, and stopping of detonation etc. Particularly, the application of controlled blasting and air-decking can be carried out without restriction while maintaining the safety of the slurry or emulsion explosives (**110**).

11 Claims, 9 Drawing Sheets

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F42B 1/032 (2006.01)
F42D 1/08 (2006.01)
F42D 3/04 (2006.01)

(58) **Field of Classification Search**
CPC F42B 3/10; F42B 3/26; F42B 1/00; F42B 1/028; F42B 1/032
USPC 102/312, 275.4, 275.5, 301, 302, 331, 102/318, 333, 306, 307, 3, 10; 175/2, 24, 175/57, 4.55–4.59; 702/11; 89/1.15
See application file for complete search history.

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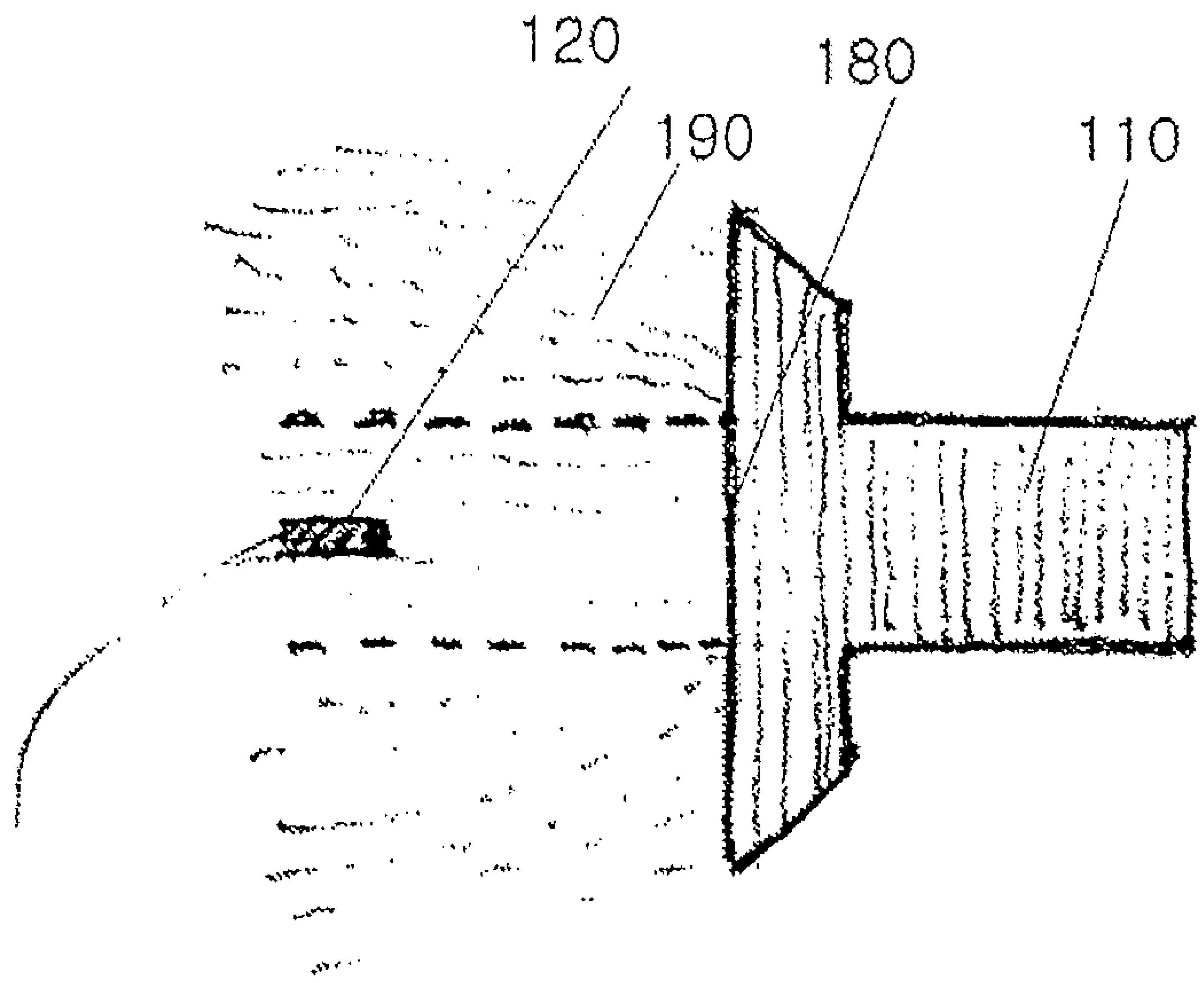

FIG. 1A

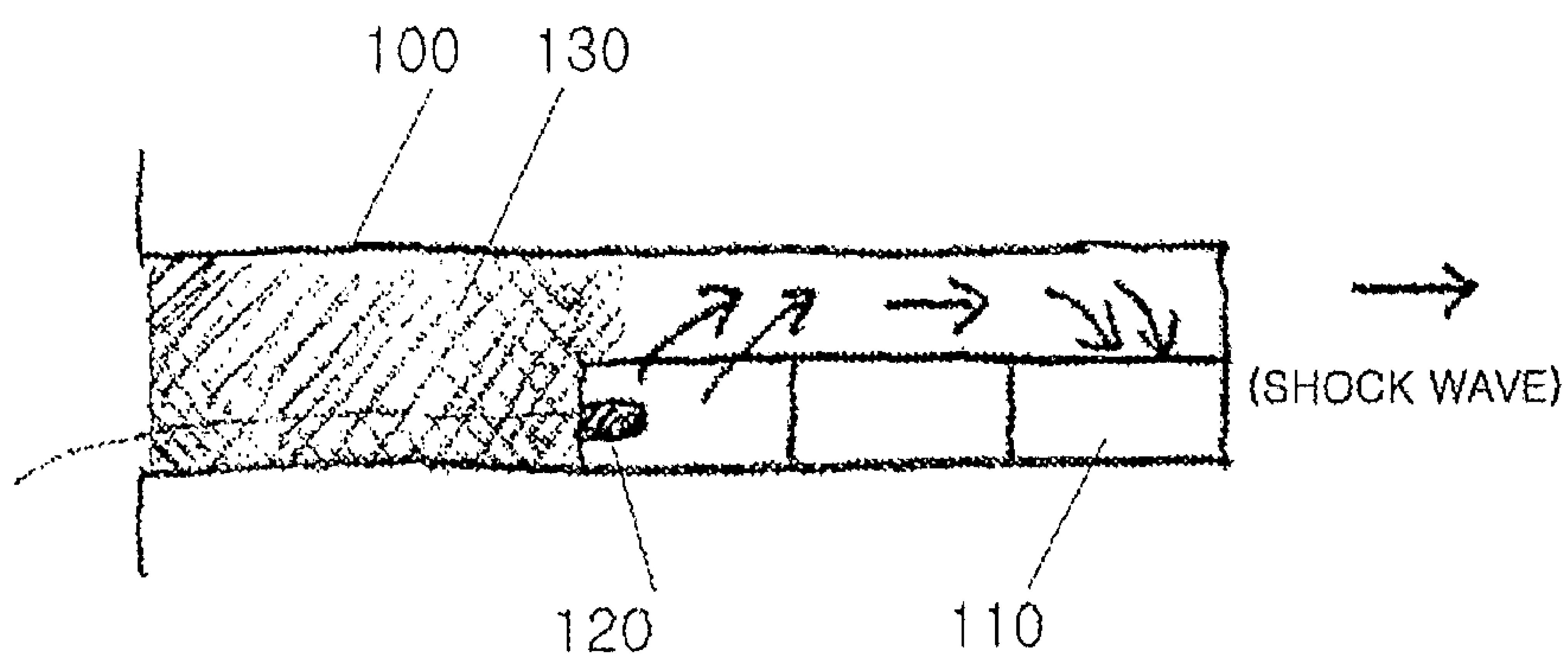

FIG. 1B

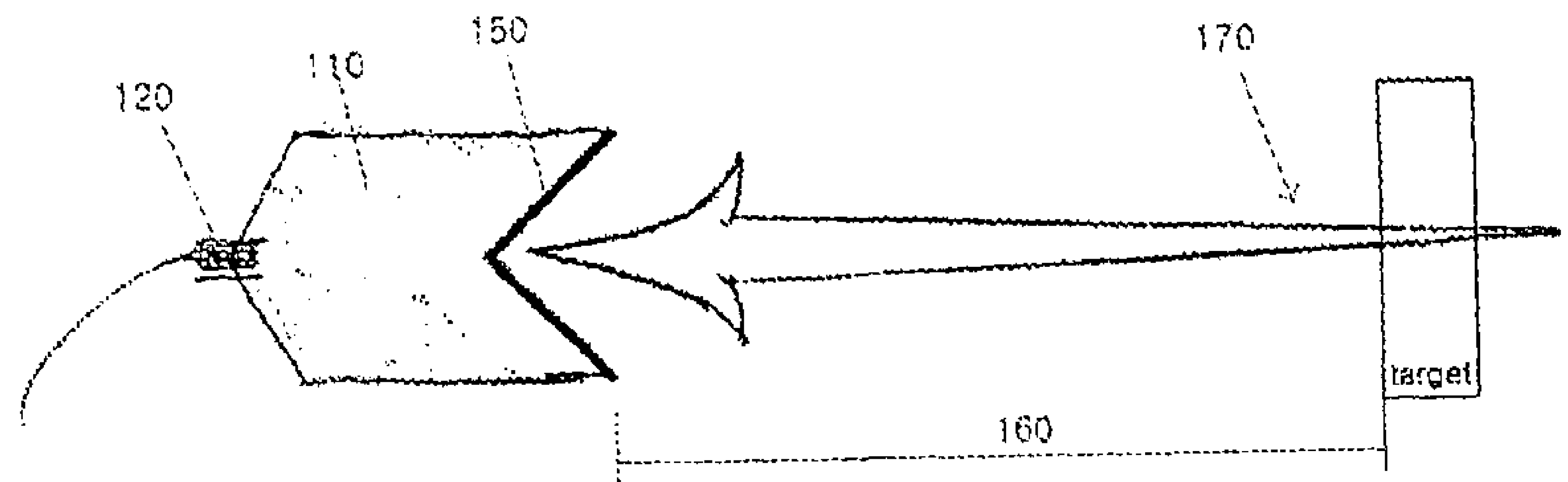

FIG. 1C

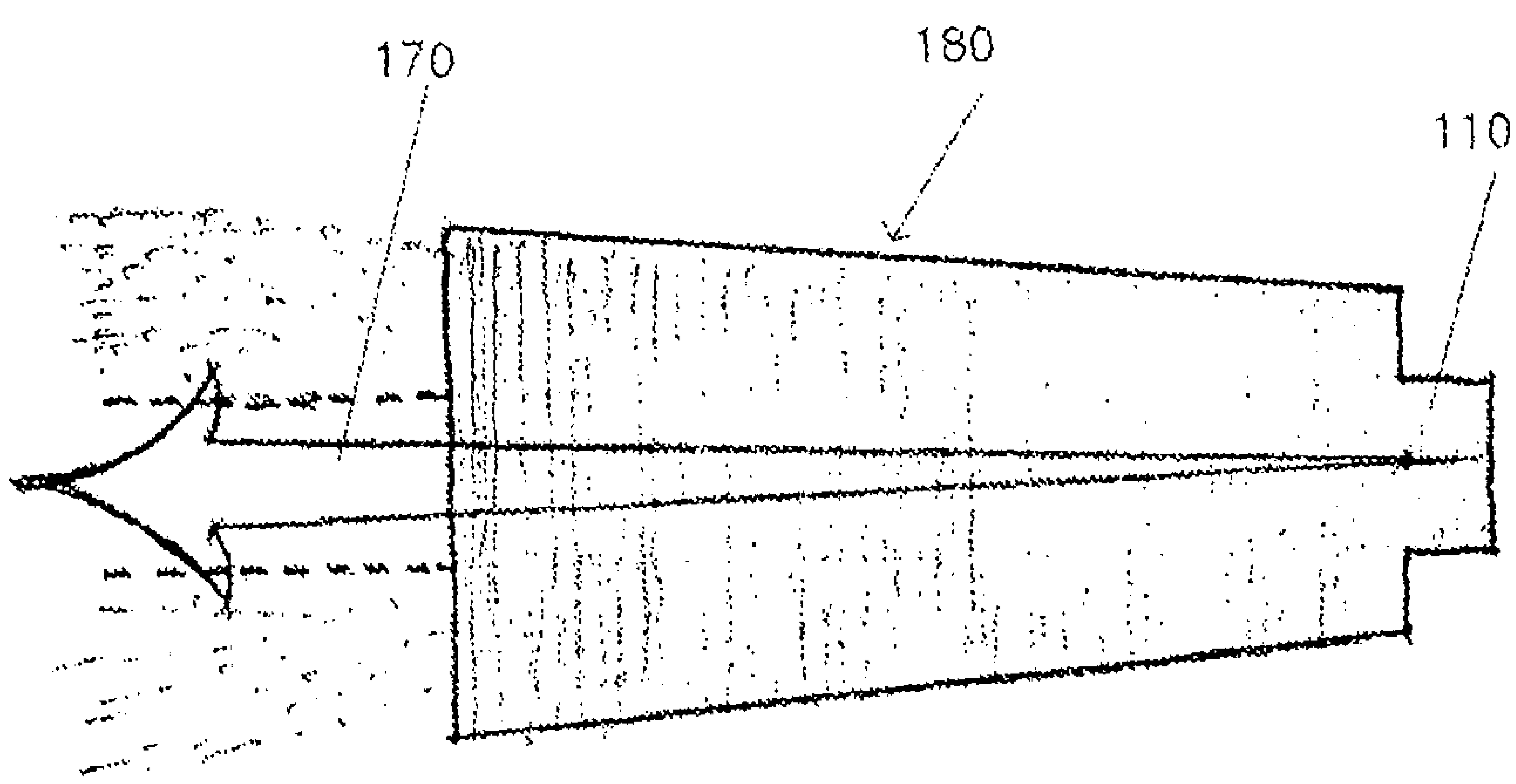

FIG. 1D

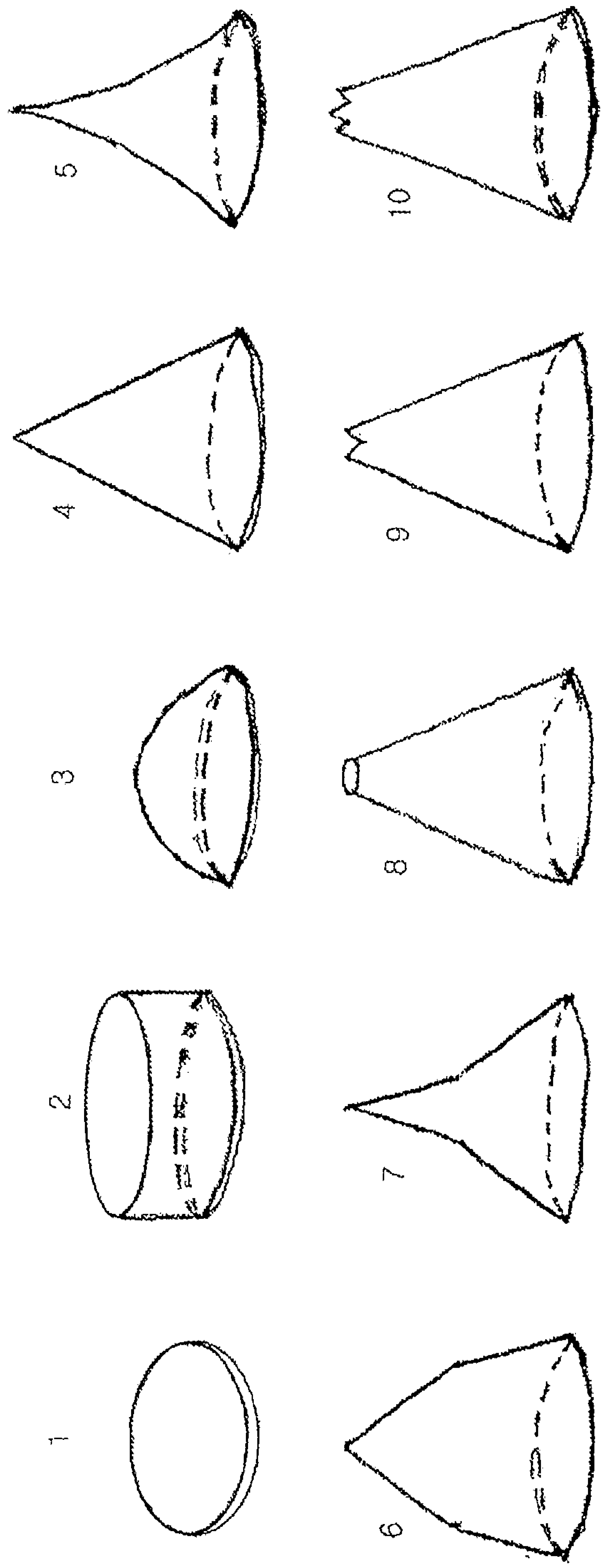

FIG. 2A

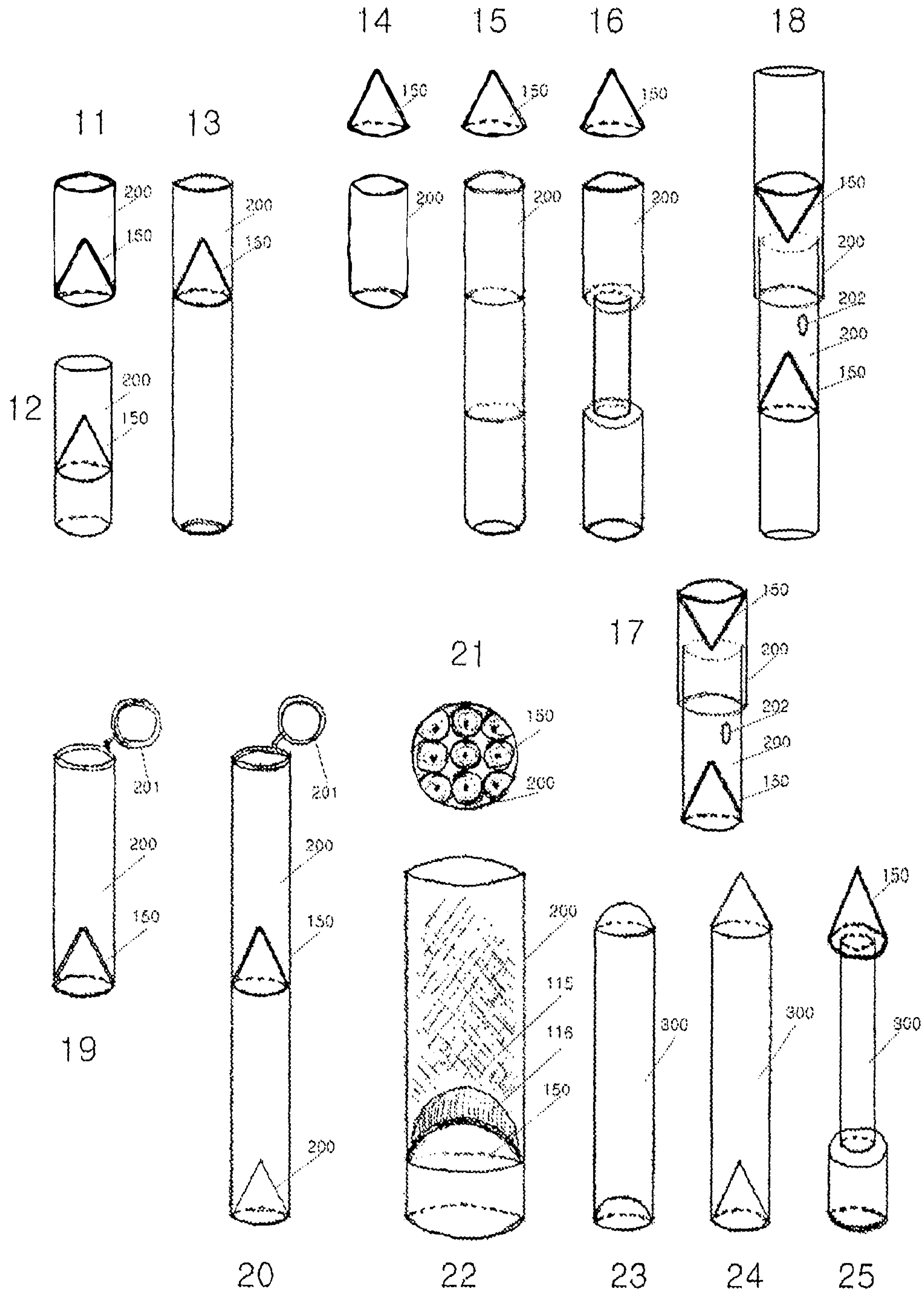

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FIG. 2B

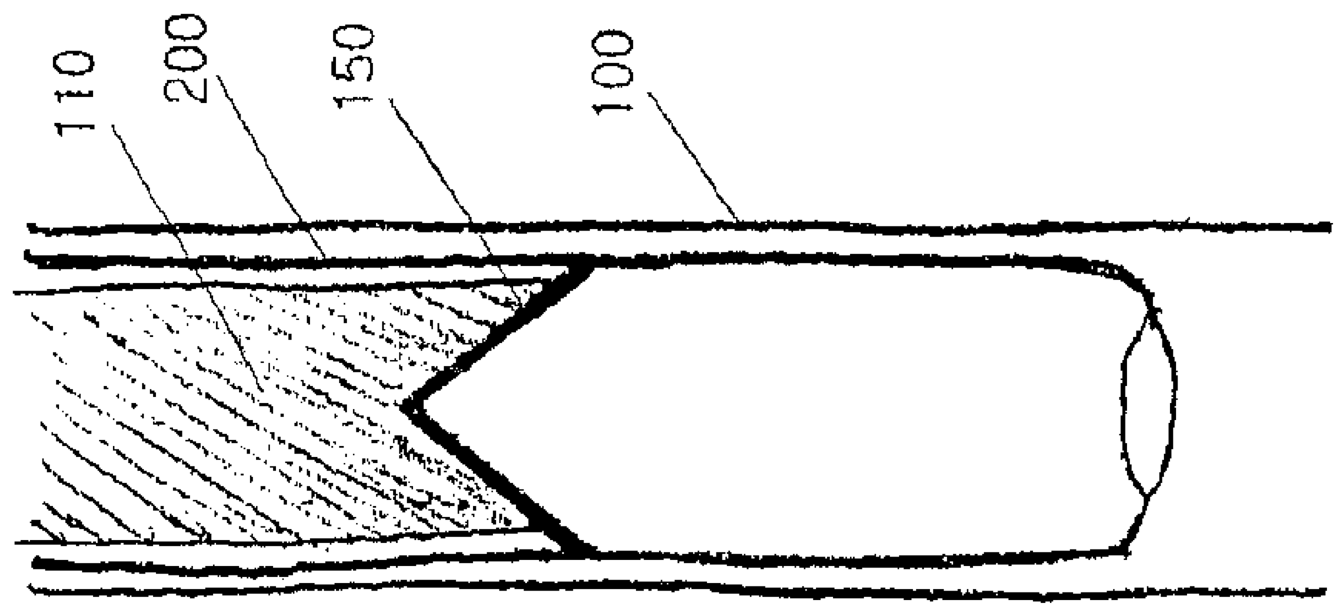

FIG 3C

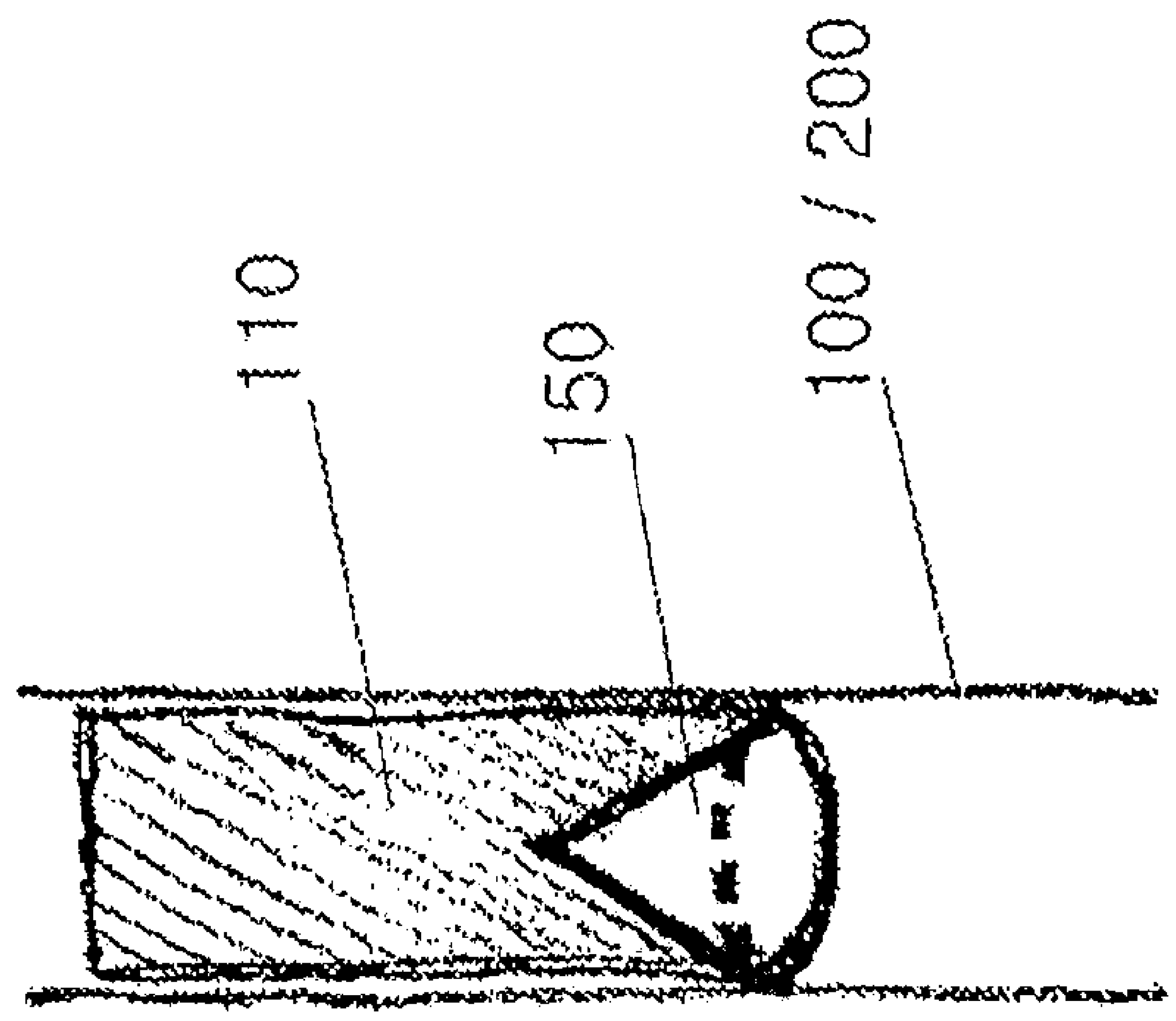

FIG. 3B

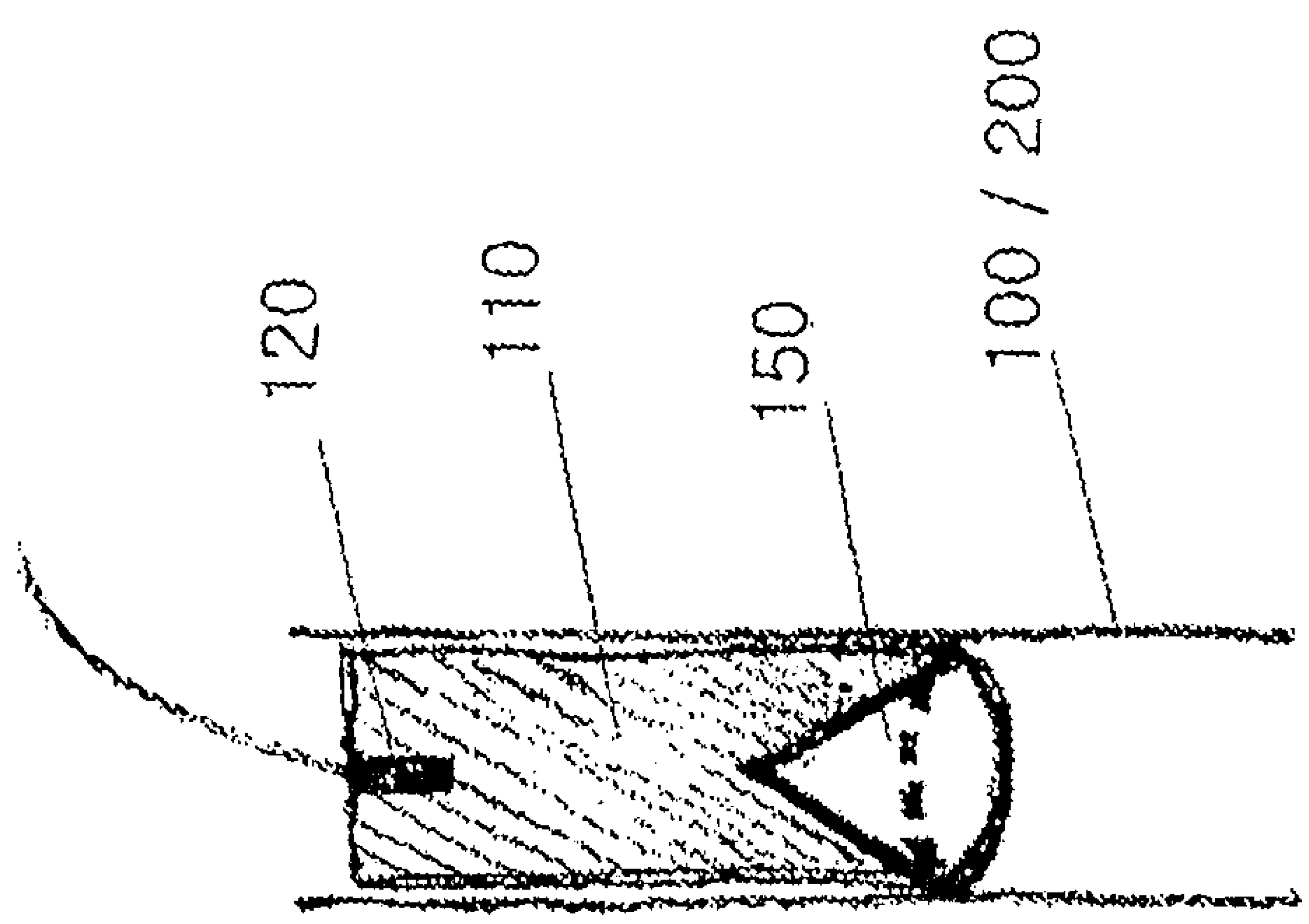

FIG 3A

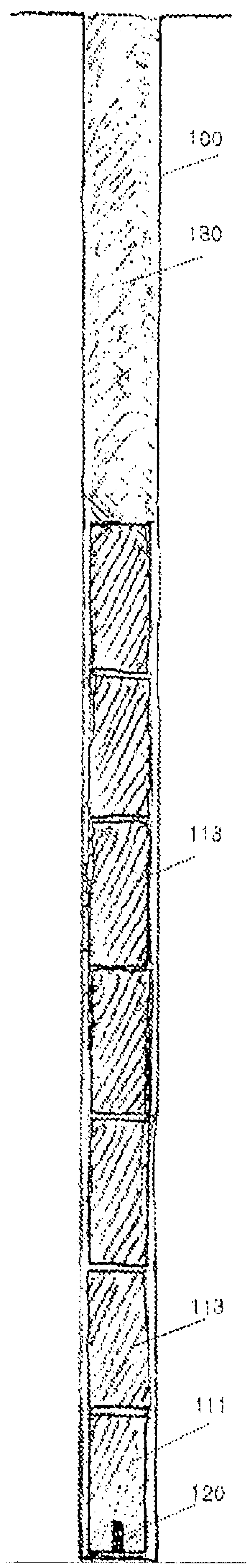

FIG. 4A

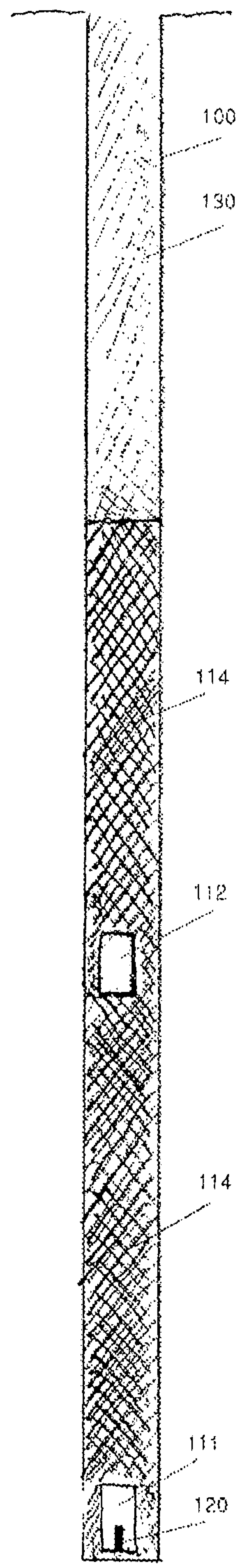

FIG. 4B

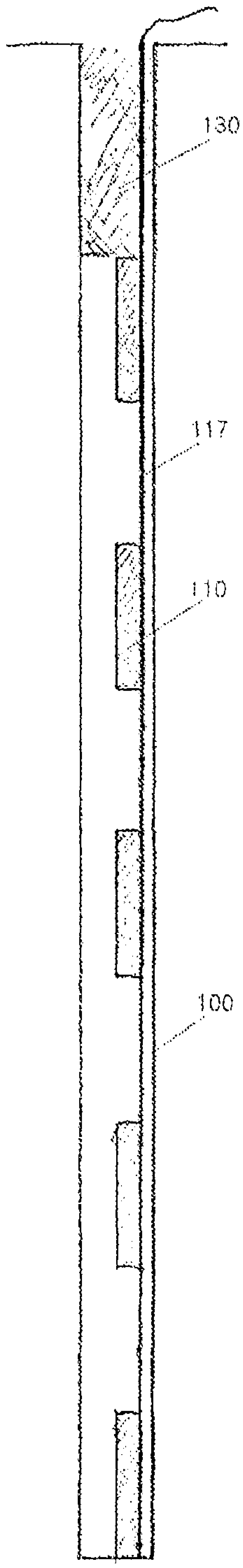

FIG. 4C

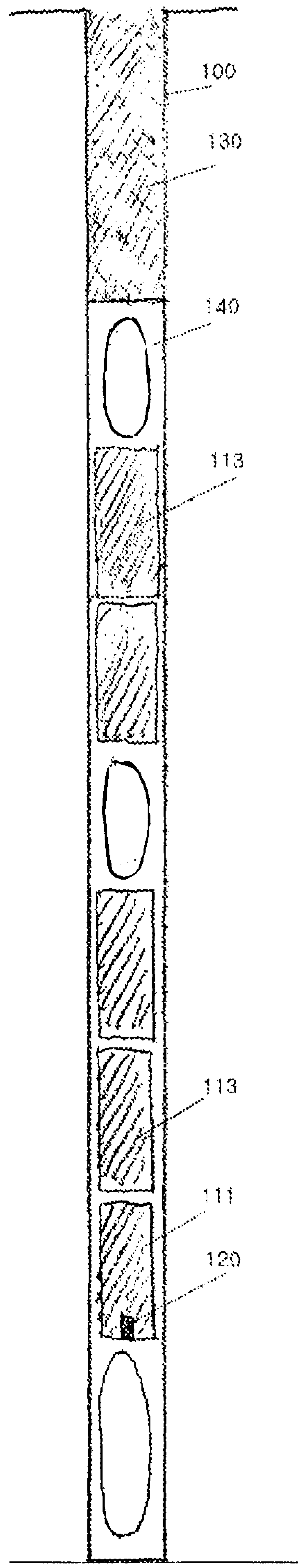

FIG. 4D

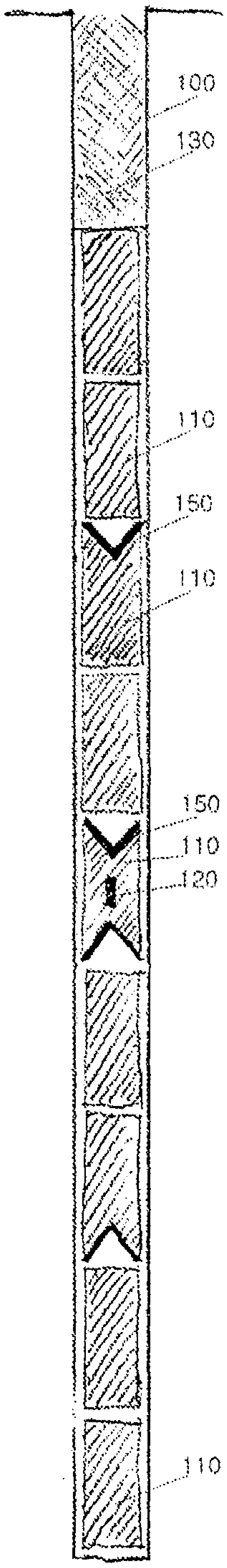
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FIG. 5A

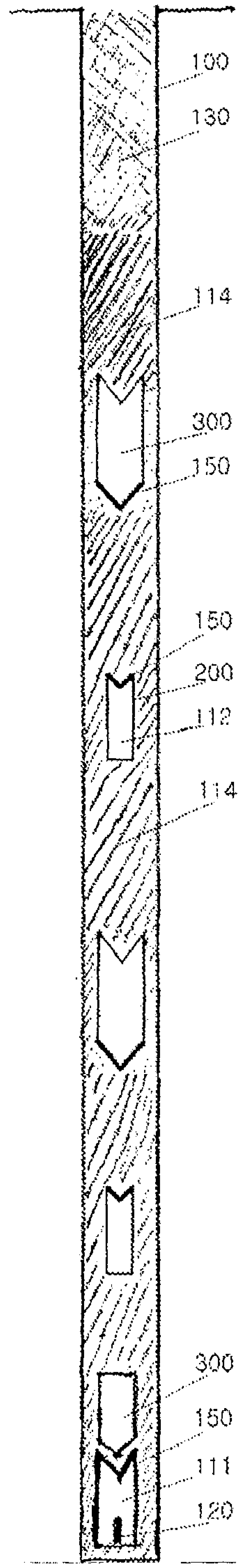
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FIG. 5B

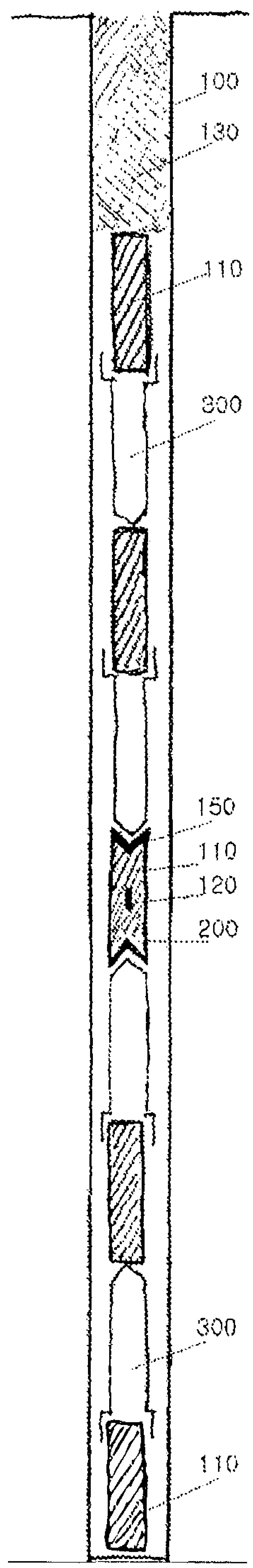
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FIG. 5C

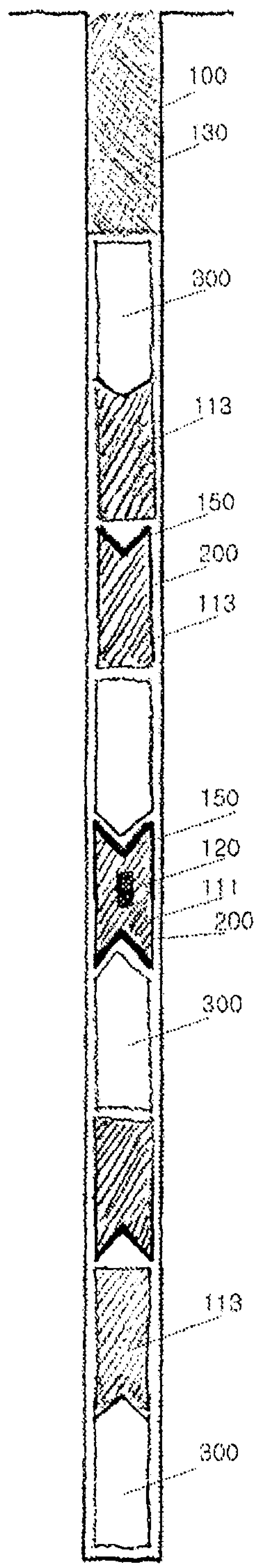
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FIG. 5D

METHOD OF BLASTING USING JET UNITS CHARGED IN A BLAST-HOLE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a U.S. national stage application claiming priority to PCT Application No. PCT/IB2019/058930, filed on Oct. 20, 2019 which claims priority to Korean Application Nos. 10-2019-0078427, filed on Jun. 30, 2019 and 10-2018-0126506, filed on Oct. 23, 2018, all of which are incorporated herein by reference in their entireties.

FIELD OF THE DISCLOSURE

This invention relates to blasting with explosives and more particularly to a blast-hole blasting method, employing a jet unit applying the shaped charge effect, to realize the ideal mechanism of the explosion and breakage analysis.

BACKGROUND OF THE DISCLOSURE

The history of blasting can be divided into the development of explosives and detonators, and the changes in their use. And so far, better blasting methods have been pursued with imagination based on observation of various phenomena.

Explosives have developed from black powder to dynamite, ANFO, slurry, emulsion, and so forth while similarly, the evolution of the electric detonator, non-electric detonator, and electronic detonator have continued since the invention of the blasting cap and detonator. Thus, the safety of explosives and the precision of the detonator have improved greatly. As for the technological progress of blasting, the blasting of the explosives charged in a blast-hole was established in the 17th century. Ensuing the observation of various phenomena, an air-deck method utilizing analytical detonation reactions was implemented, and research on a jet-powered shaped charge continued.

Of particular note, in 1893, when Knox discovered and patented that void space (air-deck) inside the blast-hole increased the efficiency of blasting charged with gunpowder. Regarding the detonator, in 1886, G. Bloem patented the formation of a hemispherical base of the detonator to increase the force of detonation.

According to the analysis of macroscopic mechanisms known to date, rocks are cracked up to 9 ms due to the dynamic and static effects of the explosion reaction. Movement of the crushed rock begins after 9 ms, and the crater production is completed in 15~30 ms.

In addition, observation of the air-deck's microscopic mechanisms has been reported to show that shock waves within 4~8 ms have a decisive effect on the fracturing of the rock. [Liu, L., Katsabanis P. D. (1996), Numerical modeling of the effects of air-decking/decoupling in production and controlled blasting. *Rock Fragmentation by Blasting*, Monhanty (ed.), Balkema, Rotterdam, pp. 319-330].

The development of the basic principle of the shaped charge began much earlier and took longer than that of the air-deck. The fundamental structure of the modern-day shaped charge (incorporating the stand-off distance starting with the observation of the cavity effect) took roughly 150 years to establish. [Kennedy, D. R. (1990), *History of The Shaped Charge Effect: The First* 100 *Years*, Defense Technical Information Center, pp. 3-14]. In the process, a number of invention patents have been proposed.

On the other hand, the detonating action of the detonator can be divided into fragments, heat, and shock waves. Regarding the detonation of cap sensitive explosives, fragments play the most important role in detonating explosives. It is reported that ammonium nitrate detonates at a distance of 1 m by the fragments in experiment.

In the jet of the shaped charge effect, a shock wave generated when the explosive is detonated and transmitted to the liner, and the collapsed liner forms the jet of high temperature and high pressure in the axial direction. The stand-off distance between the liner and the target further enhances the effect. For metal liners, the jet temperature is above 500 degrees and the speed reaches 12.5 km/s, more than twice the fragments velocity of the detonator.

SUMMARY OF THE DISCLOSURE

In accordance with the analytical observation and practical application of drilling blasting to date, the most ideal mechanism is to complete at once, on a molecular basis, the detonation reaction of a charged explosive before the destruction of the blast-hole wall proceeds. Consequently, it is possible to complete the cracking and crushing of the blasting object by converting both the shock wave energy of the primary detonation reaction and the chemical energy of the secondary reaction product into kinetic energy. In other words, to reduce the completion time of the detonation reaction of the charged explosives, increase the degree of completeness, and induction of the shock wave emission of chemical products in accordance with the detonation reaction will lengthen the duration of the reverberation significantly.

However, concerning the current blast-hole blasting method, two factors hinder the progress of the ideal mechanism. These can be divided into the manufacturing and practical limitations of the explosives and detonators.

Regarding explosives, the explosion of slurry and emulsion explosives (which currently occupies most of the industrial explosives with superior stability compared to dynamite) have a manufacturing limitation based on the hot spot theory by adiabatic compression of bubbles. In terms of detonation, the precision and accuracy of the detonator have reached 1 ms, but its role is only fulfilled at the moment of detonation and propagation is conceptualized as being dependent on the sympathetic detonation of the loading charge.

For this reason, the explosive energy cannot be efficiently used in blast-hole blasting. There have been disadvantage phenomena such as the channel effect and dead-pressing phenomenon or deceleration and detonation failure in the case of narrow drilling pattern or deep holes, in the use of various sites such as bench blasting, tunnel blasting, and underwater blasting. In particular, the air-deck charging method is more efficient at using 10-30% of the charged explosives in theory, however, in practice, the smaller the diameter and deeper the depth of the blast-holes, the more frequently the problems occur, thus making the result less efficient than the conventional method.

Concerning this circumstance, U.S. Pat. No. 6,330,860 still does not compromise the borrowed use of the early air-deck discovery and fails to account for the loss of detonation velocity and power in sympathetic detonation. Thus, it does not necessarily provide a practical alternative, which this invention addresses. U.S. Pat. No. 5,705,768 is borrowed without developing upon the basic form of the shaped charge consisting of the existing housing, explosives, detonator, and liner. There is no use of the stand-off distance;

accounting for only the concept of direction and no concept of speed. The role of the liner is also limited to only the cavity effect and not the jet effect. The use of the hemispherical liner with half the speed of the jet compared to the cone, and the jet effect using a high speed of the conical liner is also negatively taught so that it is difficult to achieve the effect of sufficient jet detonation. Kennedy's report above is reminiscent of the WASAG (1910) patent, which applied the cavity effect only to direct fracturing, as it has been continuously used ineffectively so far in blast-hole blasting. In other words, it is not the principle of the shaped charge but only part of the shape from the shaped charge.

In this method, both patents apply special phenomena from the history of blasting, each with its own limitations, suggesting opposite directions for the application and implementation of the ideal concept of blast-hole blasting. Such methods are conditioned on the limitations of explosives manufacturing according to the hot spot theory and the conceptual limits of the detonator's function, which rely on the sympathetic detonation of blast-hole blasting. In addition, the explosive energy cannot be efficiently used and the application to various blasting environments or to other charging methods such as air-decks exposes many problems.

The present invention is to provide a blasting method using a jet unit in which the shaped charge effect is applied as a method of practicing the ideal mechanism of blast-hole blasting based on the analysis of the observations described above.

In the history of blast-hole blasting, many better methods have been proposed so far, but no technical solution has been provided for the concept of ideal blasting by analysis of observations. The reason for this is that the analysis was difficult at the time of discovery of both the two phenomena mentioned above. The use of black powder and dynamite may have been the reason for no apparent need for consideration of the dead-pressure phenomena of explosives produced on the basis of the hot-spot theory or for the widespread application of the air-deck phenomenon.

Liners, spacers, and fittings are provided to make a jet unit that acts as explosives and a detonator in blast-hole blasting. The liner can be made of materials such as metal, plastic, ceramic, or glass, etc., which are capable of emitting a jet during the detonation reaction. The shape of the liner is planar, spherical, conical, etc. which can vary the speed, length and width of the cross-section of the emitted jets, depending on the intended application. Primarily, cones with a vertex angle of 40 to 90 degrees which the generatrix is straight or curved, are sufficient to induce jet emission. The spacers and fittings can be made of plastic and materials similar to plastic or environmentally friendly materials. The spacers' end portion can be shaped like the liner to support the liner or other spacers and to induce the cavity effect in the charged explosives. One side of the fittings are designed to accommodate primers, boosters, or charged explosives, while also attaching the liner in close contact, while the other side can be further extended to form a stand-off distance, and/or to accommodate explosives or spacers.

According to the predetermined plan, drill the blast-hole(s) on the object of fracture such as rock or concrete. Regarding the methods of charging the jet unit for jet detonation, one or more primers, boosters, or column charges are loaded in the blast holes; mount at least one liner to the loaded explosives for jet ignition; form empty spaces between the explosives to be used as a stand-off distance and an air-deck. The length is adjusted with respect to the strength of the rock, drilling patterns, and types of explosives. In this case, attach or mount liners using a spacer or fitting to increase workability. Double check the charge, detonate the primer, and complete propagation as the jet is released by the liner for detonation.

The jet detonation proceeds faster than the detonation of the charged explosive, and exceeds the propagation speed of the shock wave (through the air gap) between the charge and blast-hole, and the released jet fragments and its energy detonate the charges in the blast-hole rapidly. In addition, the detonation reaction of the charged explosives propagates in all directions along the axis to maximize efficiency.

As such, the jet unit overcomes the performance limits of explosives manufacturing, and the conceptual limits of detonators' functionalities, and also improves the channel effect, and dead pressing, and prevents loss of power and halt of detonation, etc. The application of controlled blasting and air-decking can be carried out without restriction while maintaining the safety of slurry or emulsion explosives.

In particular, microscopic observation of rock breakage by the air-deck charging method has proven to have a decisive impact on shock waves within 4-8 ms. Prerequisites for this are to reduce the completion time of the detonation reaction of the explosives, increase their maturity, and induce and sustain the shock waves release of chemical products following the detonation reaction. The jet unit reduces the completion time of the detonation reaction and increases the degree of completion. The stand-off distance further accelerates the speed of the jet, and combined with the proper arrangement of the air-deck, also ensures that the chemical product of the detonation reaction releases its energy as a shock wave greatly improving its reverberation.

The jet unit improves the efficiency of explosives in blast-hole blasting, thereby reducing the influence on adjacent holes during tunnel blasting and increasing the rate of excavation and being advantageous for over-break management. It also increases the productivity and workability by overcoming the effects of the detonation due to water pressure in underwater blasting and can be an essential application during controlled blasting. When applied to all blast-hole blasting, explosive efficiency can be increased to improve productivity and prevent pollution and environmental issues such as vibration and noise.

In blast-hole blasting, the explosion using the jet unit could lead to the reconsideration and change of basic design elements such as sensitivity, pressure resistance, and detonation velocity, etc., in the manufacturing method of industrial explosives. In addition to the classification of industrial explosives (which are classified currently cap sensitive and booster sensitive), it will be possible to manufacture safer jet sensitive explosives by adapting the activation energy to the jet detonation. Furthermore, it will accelerate the methods of achieving said efficiency by detonating the loading explosive at once on the molecular basis.

The configuration, operation, and applications of the present invention will be described with reference to the accompanying Figures.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is a sectional side view illustrating the detonation reaction zone by the detonator.

FIG. **1**B is a sectional side view illustrating the dead-pressing phenomenon by the channel effect.

FIG. **1**C is a sectional side view illustrating the jet generated by the shaped charge.

FIG. **1**D is a sectional side view illustrating the detonation reaction zone by the jet.

FIG. **2**A is a diagram showing the shapes of detonation liners.

FIG. **2**B is a diagram showing the shapes of fittings and spacers.

FIG. **3**A is a diagram showing a detonator on the jet unit.

FIG. **3**B is a diagram showing the basic shape of the jet unit.

FIG. **3**C is a diagram showing the basic shape of the jet unit with the stand-off distance.

FIG. **4**A is a sectional side view of a charging method of cartridge explosives according to the prior art.

FIG. **4**B is a sectional side view of a charging method of bulk explosives according to the prior art.

FIG. **4**C is a sectional side view of a charging method of pre-splitting according to the prior art.

FIG. **4**D is a sectional side view of a charging method of air-decking according to the prior art.

FIG. **5**A is a sectional side view of a charging method of cartridge explosives in accordance with an embodiment of the present invention.

FIG. **5**B is a sectional side view of a charging method of bulk explosives in accordance with an embodiment of the present invention.

FIG. **5**C is a sectional side view of a charging method of pre-splitting in accordance with an embodiment of the present invention.

FIG. **5**D is a sectional side view of a charging method of air-decking in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION

FIGS. **1**A to **1**D illustrate the problems of the prior art and their solutions provided by a detonating jet.

FIG. **1**A shows the detonation reaction caused by the propagation of the explosives **110** of the detonator **120**. Shock wave and explosion product **190** are generated in the detonation reaction zone **180**.

FIG. **1**B is a diagram showing the cause of the channel effect. The shock wave originating from the detonation of the detonator **120** passes between the blast-hole **100** and the explosive **110** to reach the explosive **110** which has not yet been detonated, thereby reducing the sensitivity. This reduces the efficiency of explosives **110** and results in misfired charges. This phenomenon becomes evident when using slurry or emulsion explosives manufactured on the basis of hot spot theory in small tunnels. This reduces efficiency in controlled blasting and bench blasting in construction and mining and limits the potential for wider implementation of air-decking.

FIG. **1**C shows the jet **170** produced when the shaped charge is detonated by the detonator **120**. The shock wave generated by the explosive **110** transmits to and collapses the liner **150**. The collapsed liner **150** forms a jet **170** of high temperature and pressure in the axial direction. The temperature of the jet **170** is above 500 degrees and the speed reaches 12.5 km/s, more than twice the speed of the fragments of the detonator **120**. At this time, the stand-off distance **160**, which is the distance from the liner **150** to the target, further accelerates the jet **170** emitted by the liner **150**.

FIG. **1**D shows the detonation reaction zone **180** of cartridge explosives **110** which are detonated by the jet **170** emitted by the shaped charge. As such, it can be seen that the detonation reaction zone **180** by the jet **170** is greatly different from that by the detonator **120** in FIG. **1**A. The detonation by the jet **170** of the liner **150** proceeds faster than the propagation of the explosion by the conventional sympathetic detonation in the blast-hole **100** blasting, and exceeds the propagation speed of the pressure by the shock wave through the air gap of the blast-hole **100**.

As described above, detonation by the jet unit of FIGS. **3**A to **3**C is to reduce the completion time of the detonation reaction and to increase the degree of completion, to effectively use the explosive **110**, and to improve the channel effect, dead pressure phenomenon, and prevent the loss of power and halt of detonation. This is because the emitted jet **170** fragments and their energy not only detonate explosives **110** in the blast-hole **100** in a short time, but the detonation reaction of the charged explosives **110** occurs all along the axis, maximizing its efficiency.

FIGS. **2**A and **2**B are described with reference to the diagrams for the production of liners (**1~10**), fittings (**11~22**), and spacers (**23~25**). In the practice of the present invention, it can be loaded by simply attaching the liner (**1~10**) to the explosives **110**, but also as shown in FIG. **2**B for convenience and workability of mounting the liner (**1~10**), as well as forming the stand-off distance **160**. Fittings (**11~22**), such as the integral type (**11~13**), detachable type (**14~16**), bidirectional types (**17**, **18**), waterproof type (**19**, **20**), application type (**21**, **22**), and spacers (**23~25**) may be selected and applied according to the characteristics of each task. Particularly, when both ends of the spacers (**23~25**) are formed in the shape of a liner, such as a curved surface **23** or a conical shape **24**, they are suitable for supporting the liner **150** and inducing the cavity effect to the charged explosives **110**, consistent with the implication of the present method. If the diameter of the blast-hole is larger than the diameter of the fittings or the spacers in FIG. **2**B, the jet units shown in FIGS. **3**A, **3**B, and **3**C are to be installed parallel to the blast-hole by making it possible to attach a straight or circular wing to the spacer or the fitting.

FIG. **2**A shows the various shapes available for the manufacturing of the detonation liners **1** to **10**. Flat type (**1**, **2**), Curved type (**3**), Conical type (**4**), Trumpet type (**5**), Double Cone type (**6**, **7**), Flat Top type (**8**), Recessed type (**9**), Double Nipple type (**10**). The liners (**1~10**) can vary in speed, length and width of the cross-section of the jet **170**, depending on its shape. The material may be metal, plastic, ceramic or glass etc.; it emits the jet(s) **170** following detonation of the explosives **110**, depending on the characteristics such as friction or impact for work safety, and the temperature of the jet(s) **170**.

FIG. **2**B shows the various shapes available for the manufacturing of the fittings (**11~22**) and spacers (**23~25**): Integral type of fitting and liner (**11**), Integral type of fitting and liner with an extension (**12**), Integral type of fitting and liner with stand-off distance (**13**), Detachable type of fitting and liner (**14**), Detachable type of fitting and liner with stand-off distance (**15**, **16**), Bidirectional fitting and liner (**17**), Bidirectional fitting and liner with stand-off distance (**18**), Waterproof fitting and liner (**19**), Waterproof fitting and liner with stand-off distance (**20**), Spherical shaped fitting and liner (**21**), Application type for centralized jet (**22**), Hemispherical shaped spacer (**23**), Conical shaped spacer (**24**), Spacer for supporting liner and with cartridge receiver (**25**). The bidirectional fittings (**17**, **18**) may mount the detonator **120** through the detonator insert **202**. Waterproof fittings (**19**, **20**) can be used by inserting or filling explosives **110** and closing the lid **203** for waterproofing. The spherical **21** can be used for large diameters, while the application type **22** can be used for high-explosives **115** and low-explosives **116**, where the jet must be concentrated in one place. The fittings (**11~22**) and spacers (**23~25**) may be made of plastic materials similar to plastic or eco-friendly materials.

FIGS. **3**A, **3**B, and **3**C are jet units for jet detonation in blast-hole blasting. They act as explosives **110** and detonators **120**, enabling the ideal blast-hole blasting following observation and analysis from the constraint of the implicit concept that "all propagation of detonation depends on the sympathetic detonation between charged explosives" since the invention of detonators **120**. As shown in FIG. **3**C, the fittings with (**13**, **15**, **16**, **18**, **20**), and without (**11**, **12**, **14**, **17**, **19**, **22**) the stand-off distance **160** may be more effective and convenient. The stand-off distance **160** accelerates the jet **170** and serves as the space for the air-deck **140**, making it possible to use the explosives **110** more efficiently than the conventional air-deck **140** method.

For jet detonation in blast-hole blasting: Firstly, the liner **150** is attached to the explosives **110**, primer **111**, booster **112**, or column charge **113**, mainly by using a straight or curved line of the generatrix of the cone to sufficiently induce the emission of the jet **170**. The method of attaching the liner **150** is as shown in FIG. **3**A. In the case of a cone shape, the rotation axis of the cone **150** coincides with the supposed long axis of the blast-hole **100**, the cartridge explosives **110**, the detonator **120**, and the underside of the explosives to be attached. It should be made sure that the explosives **110** are in close contact with the outer surface of the liner **150**.

Secondly, after attaching the liner **150**, it is possible to induce acceleration on the jet **170** released by the liner **150** by setting the stand-off distance **160**. This amplifies the detonation force of the jet **170**. In the case of long-hole blasting, this has the advantage of further accelerating the detonation. In the case of the conical liner **4**, the stand-off distance **160** may be applied at 2 to 8 times the diameter depending on the material to be manufactured for the penetration or cutting of the steel. Shorter or longer alterations of the stand-off distance do not interfere with the detonation of the explosives. As a simple test blasting according to the situation of the site, it can account for various variables such as the material and shape of the liner **150**.

Thirdly, in the above-mentioned bench blasting, tunnel blasting, controlled blasting, underwater blasting, etc., determines the loading amount according to the working situation, attach the liner **150**, set the stand-off distance **160**, and then use spacer (**23~25**) between the charges. By doing this, the efficiency of various blasting methods can be improved, and in particular, the air-deck method can be widely applied. Various types of liners (**1~10**), fittings (**11~22**), and spacers (**23~25**) shown in FIGS. **2**A and **2**B may be selected according to the types and characteristics of the above operations.

FIGS. **4**A to **4**D are conventional methods, all of which only rely on sympathetic detonation for the charged explosives (**111~114**). With regard to an issue in blast-hole blasting, the shock wave energy following the crushing of the blast-hole wall is expended in pollution.

FIG. **4**A is a representative method of the prior art; after placing the primer **111** with a detonator **120** at the bottom of a blast-hole **100**, the column charge **113** located on the top, and stemming **130**. In some cases, the primer **111** may be placed in the middle of a charge or just before the stemming **130**.

FIG. **4**B is a conventional technique in which a primer **111** is placed with a detonator **120** at the bottom of the blast-hole with loaded bulk explosives **114**. In most cases, to increase the power of detonation, a booster **112** is placed in the middle of the charge. Even if the booster **112** is placed in the middle of the charge, the efficiency of the blasting is limited as a method of sympathetic detonation, and the potential wide implementation of the air-deck is restricted. When applied to large-scale bench blasting, the loss of power and halt of detonation are not distinctly recognizable, but there is much room for improvement from the perspective of the ideal method of a detonation reaction.

FIG. **4**C is a method of pre-splitting, which is a kind of controlled blasting of the prior art. The explosives **110** (with diameters smaller than the blast-holes diameters) attach to the detonating cord **117** at regular intervals to detonate them. Controlled blasting is carried out by decoupling charges in order to soften the shockwave during the detonation. When the air-deck method is applied to avoid noise generated by the detonating cord **117**, the workability is inferior due to the channel effect.

FIG. **4**D is the air-deck **140** charging method of the prior art to charge the primer **111** and column charge **113**. It is mainly arranged with the empty space at the bottom, center, and top of the charge. Thus, the column charge **113** depends on the sympathetic detonation, reducing the detonation velocity; thereby restricting the use of the air-deck. Regarding the ideal use of the detonation reaction, there is much room for improvement as shown in FIG. **4**B.

FIGS. **5**A to **5**D are charging methods for jet detonation in the present invention, loading a jet unit acting as explosives **110** and a detonator **120** in a blast-hole **100**. The jet unit concentrates and amplifies the detonation force of the detonator **120**; it reduces the completion time of the detonation reaction and enhances its degree of completion. In particular, spacers **300**, such as curved **23** or conical **24** ends; the same as the liner's shape, are used to support the liner **150** and form a stand-off distance **160** and air-deck **140**. With the utilization of the jet **170** detonation and the cavity effect of the charged explosive **110**, the ideal mechanism is further enhanced.

FIG. **5**A is a method of applying the jet detonation to the simplest charging method of the prior art. The explosive **110** and detonator **120** are placed in the blast-hole **100**, and the primer **111** is placed in the middle of the charge. By deploying a jet unit that acts as an explosive **110** and a detonator **120** using the detonating liner **150**, the propagation of detonation can be further accelerated and completion time of the explosion reaction reduced. The lack of stand-off distance **160** and air-deck **140** reduce the efficiency of the explosive, but the faster detonation further enhances the explosive's power, making it more effective than conventional methods in cast blasting that require throwing.

FIG. **5**B shows a bulk explosive **114** loaded in a blast-hole **100**. A liner **150** is attached to the primer **111** and has a spacer **300** installed to induce acceleration of the jet **170**. In addition, by attaching the liner **150** to the booster **112** and spacer **300**, the propagation of the detonation can be accelerated further than the conventional method, as well as having reduced the completion time and increasing the degree of completion of the detonation, in order to enable the air-deck to be carried out without restriction.

FIG. **5**C is an example of the decoupling charge, in which the blast-hole **100** is alternately loaded with the explosives **110** and spacer **300**. The positioning of the primer **111** in the middle can reduce the completion time of detonation. In controlled blasting such as pre-splitting, cushion blasting, and smooth blasting, decoupling charges are performed. The decoupling charge is a blasting method that controls the shock wave acting on the wall of the blast-hole **100**, by using explosives **110** about 2~3 times smaller than the blast-hole diameter. The conventional method using the detonating cord **117** causes noise, and the air tube method has the problem of a sympathetic detonation. Using the liner **150** and spacer **300** according to the method of the present invention can solve the two problems mentioned above and can also be applied to quarrying by extending the stand-off distance **160** and the air-deck **140**.

FIG. **5**D illustrates an air-deck **140** charging method of the present invention, in which two-way jet units are deployed in the center of the charge. The air-deck may be placed where the degree of breakage is to be increased and selecting the position of the detonation in the middle may reduce the time for the completion of detonation. Fittings **200** and spacers **300** will allow for various modifications to the jet unit's location and air-deck charge methods. Air-decks **140** are formed by using spacers on the lower and upper part of the blast-hole **100**, and a primer **111** having the detonator **120** fixed thereto is placed in the center, and a stand-off distance **160** of the liner **150** is formed. The microscopic observation of the breakage effect by the air-deck **140** charging method has been reported to have a decisive effect on the shock wave within 4-8 ms, while jet units with the jet liner **150** reduce the completion time of the detonation reaction of the charged explosive and increase its maturity. The spacing by the stand-off distance **160** and spacer **300** is sufficient to allow the chemical product **190** of the detonation reaction to release its energy as a shock wave, and the duration of the reverberation is greatly improved. Thus, the jet detonation by the jet unit enables the ideal implementation in the practical application according to the experimental theory of blasting by analysis of the mechanism of the detonation reaction.

The above description is intended to be illustrative, not restrictive. The scope of the invention should be determined with reference to the appended claims along with the full scope of equivalents. It is anticipated and intended that future developments will occur in the art, and that the disclosed devices, kits and methods will be incorporated into such future embodiments. Thus, the invention is capable of modification and variation and is limited only by the following claims.

What is claimed is:

1. A blast-hole blasting method using an air-deck charging method, comprising one or more liner(s) for detonation are attached to (i) a primer equipped with a detonator, (ii) one or more charged explosive(s) other than said primer, or (iii) said primer and one or more charged explosive(s), and when the detonator is detonated, the jet released by the liner(s) for detonation detonates or propagates the explosion of the charged explosive(s).

2. The blast-hole blasting method according to claim **1**, wherein a stand-off distance is provided (i) between one of the liner(s) for detonation that is attached to said primer and one of the charged explosive(s) adjacent to the liner for detonation attached to said primer, (ii) between one of the liner(s) for detonation attached to a first of said charged explosive(s) and a second of said charged explosive(s) adjacent to the liner for detonation attached to the first charged explosive, or (iii) between the liner for detonation that is attached to said primer and a charged explosive adjacent to the liner for detonation attached to said primer, and between the liner for detonation attached to said first charged explosive and the second charged explosive.

3. The blast-hole blasting method according to claim **1**, wherein the liner(s) for detonation is directly attached to the primer or the charged explosive, or the liner(s) for detonation is attached to a fitting for mounting a liner and then the fitting is attached to the primer or the charged explosive.

4. The blast-hole blasting method according to claim **3**, wherein the liner for detonation is made of at least one of materials selected from the group consisting of metal, plastic, ceramic and glass.

5. The blast-hole blasting method according to claim **4**, wherein the shape of the liner for detonation is selected from the group consisting of flat type, curved type, conical type, trumpet type, double cone type, flat top type, recessed type, double nipple type.

6. A blast-hole blasting method comprising the steps of:

(i) loading a blast-hole formed on an object of fracture with one or more charged explosives and a primer equipped with a detonator;

(ii) stemming the blast-hole; and

(iii) detonating the primer,

wherein a space(s) for air-decking effect is provided at least at one of the following: a bottom of the blast-hole; between the primer and a charged explosive; between a charged explosive and another charged explosive; and between a charged explosive and stemming material, and

wherein one or more liner(s) for detonation are attached to (i) the primer, (ii) one or more charged explosive(s) other than said primer, or (iii) said primer and one or more charged explosive(s), and when the detonator is detonated, the jet released by the liners for detonation detonates or propagates the explosion of the charged explosive(s).

7. The blast-hole blasting method according to claim **6**, wherein a stand-off distance is provided (i) between one of the liner(s) for detonation that is attached to said primer and one of the charged explosive(s) adjacent to the liner for detonation attached to said primer, (ii) between one of the liner(s) for detonation attached to a first of said charged explosive(s) and a second of said charged explosive(s) adjacent to the liner for detonation attached to the first charged explosive, or (iii) between the liner for detonation that is attached to said primer and a charged explosive adjacent to the liner for detonation attached to said primer, and between the liner for detonation that is attached to said first charged explosive and the second charged explosive.

8. The blast-hole blasting method according to claim **7**, wherein the space formed by the stand-off distance plays a role as a space for air-decking effect.

9. The blast-hole blasting method according to claim **6**, wherein the liner(s) for detonation is directly attached to the primer or the charged explosive, or the liner(s) for detonation is attached to a fitting for mounting a liner and then the fitting is attached to the primer or the charged explosive.

10. The blast-hole blasting method according to claim **9**, wherein the liner for detonation is made of at least one of materials selected from the group consisting of metal, plastic, ceramic and glass.

11. The blast-hole blasting method according to claim **10**, wherein the shape of the liner for detonation is selected from the group consisting of flat type, curved type, conical type, trumpet type, double cone type, flat top type, recessed type, double nipple type.

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